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(12) UK Patent Application (19) GB (11) 2 241 302 (13) A

(43) Date of A publication 28.08.1991

(21) Application No 9006755.4

(22) Date of filing 27.03.1990

(30) Priority data
(31) 472630 (32) 26.01.1990 (33) US

(51) INT CL[5]
F16K 31/08

(52) UK CL (Edition K)
F2V VS20

(56) Documents cited
GB 2067717 A GB 1402109 A GB 0843891 A
GB 0800346 A US 3212751 A

(58) Field of search
UK CL (Edition K) F2V VS20
INT CL[5] F16K

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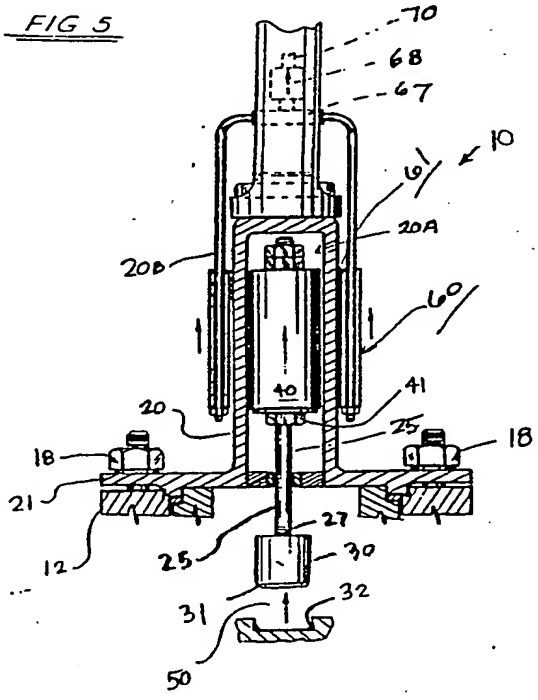
(54) Magnetically actuated valve

(57) To eliminate fugitive emissions from a valve having a valve body (12) and a vertically extending, vertically slidable stem member (25) that actuates a valving member (30) between open flow and closed flow positions in relation to a valve seat (32), the stem (25) extending generally at right angles to the overall direction of flow through the valve body (12), a bonnet (20) is affixed to the valve body (12) so as to form a fluid tight seal over the valve stem (25) and the stem is displaced by magnetic means. The upper end portion of the stem carries a large magnetically moved piston (40) and an external, preferably annular permanent magnetic member (60) slides between open flow and closed flow positions on the outside of the bonnet (20) and entrains the piston (40) to open and close the valve. A valve position indicator or transmitter may indicate or transmit the position of the valving member at all times.

FIG 5



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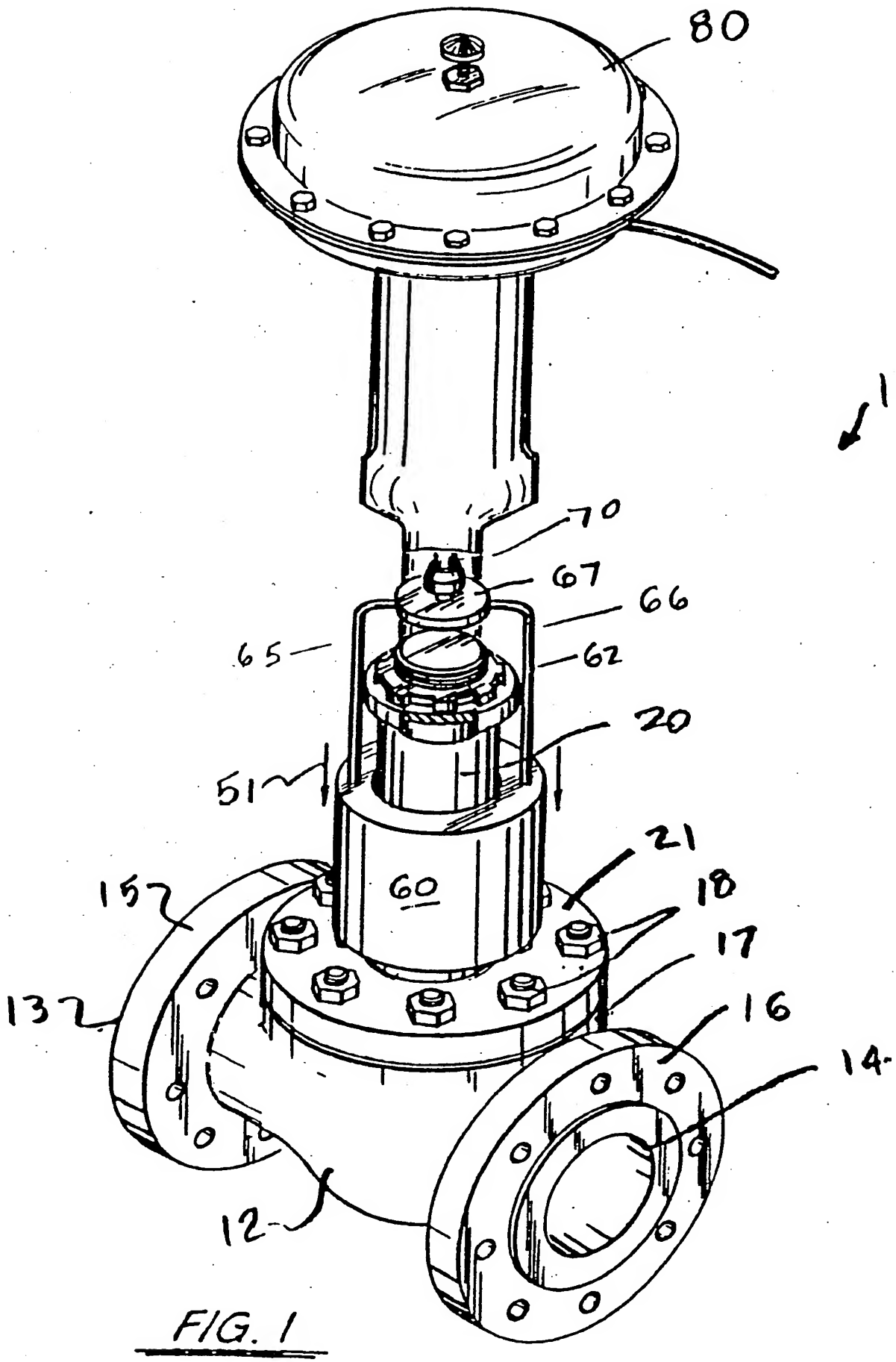

FIG. 1

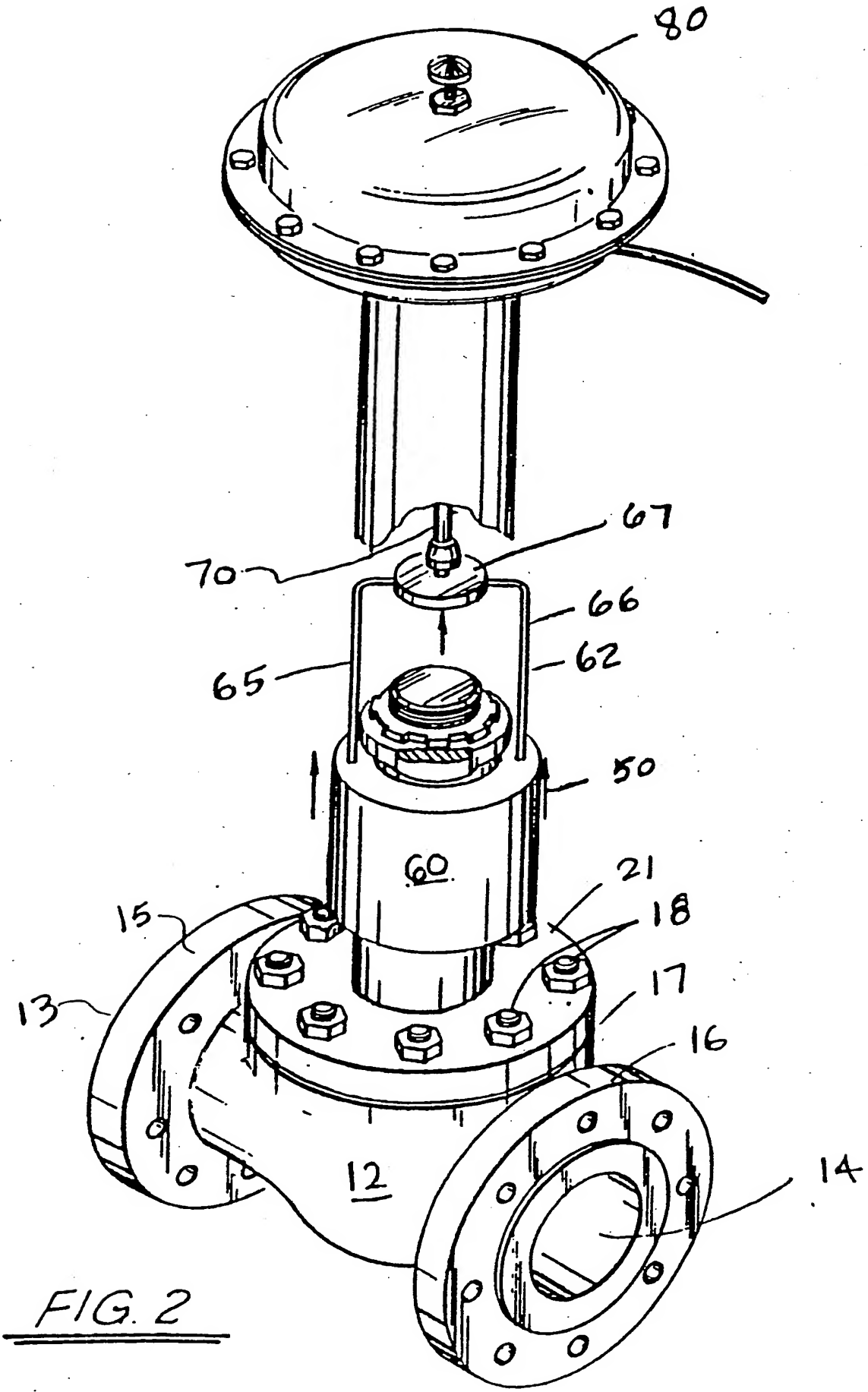

FIG. 2

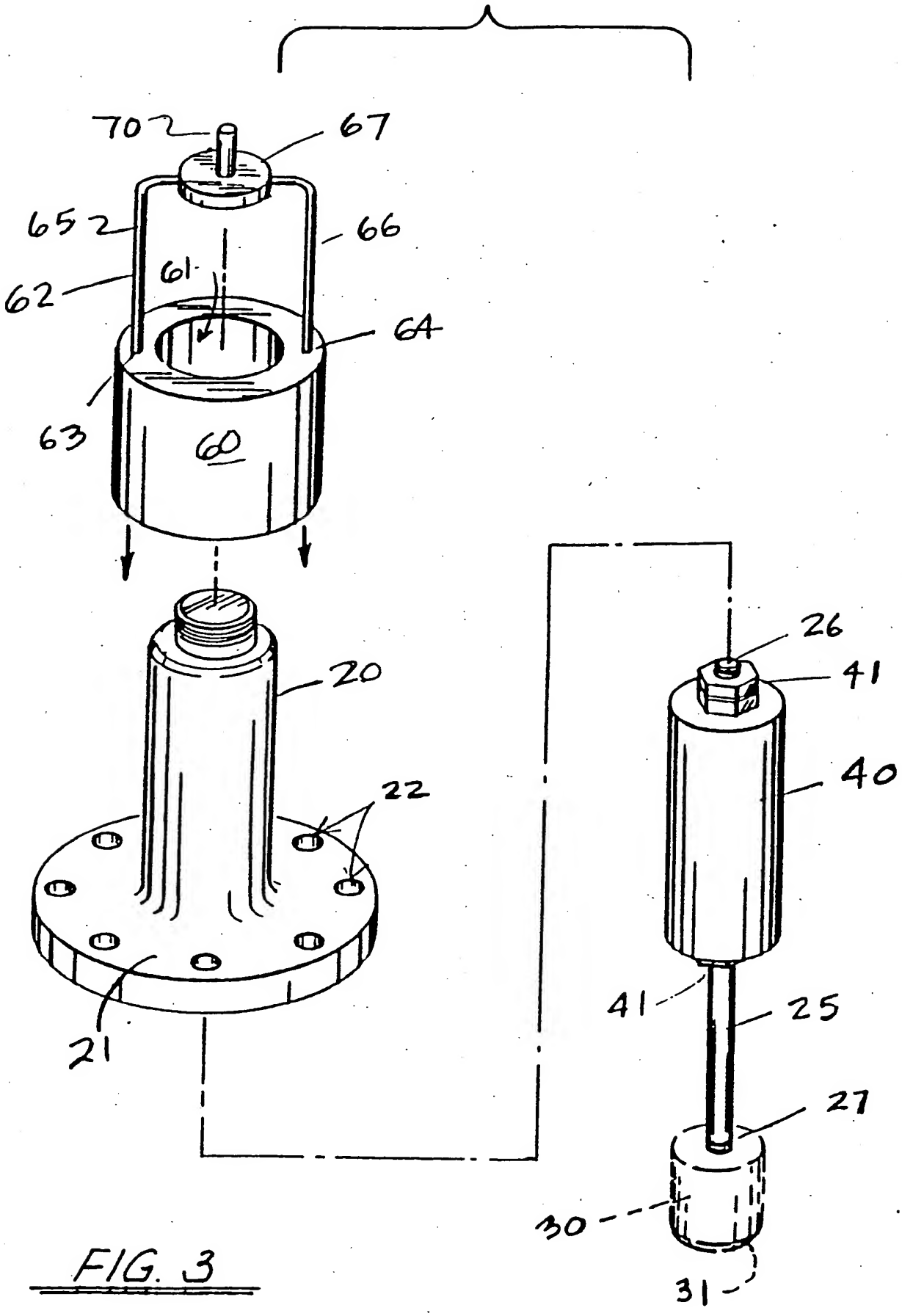

FIG. 3

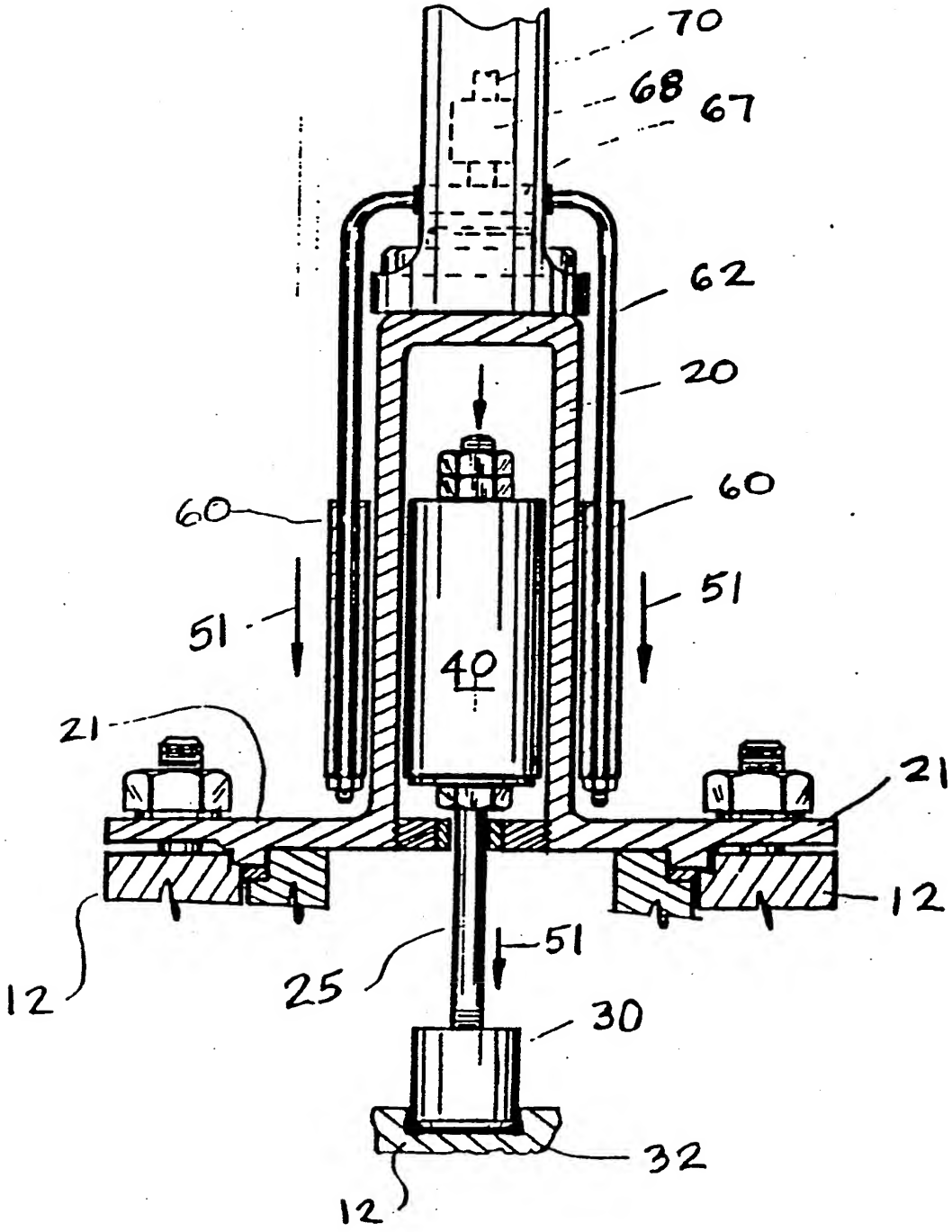

FIG. 4

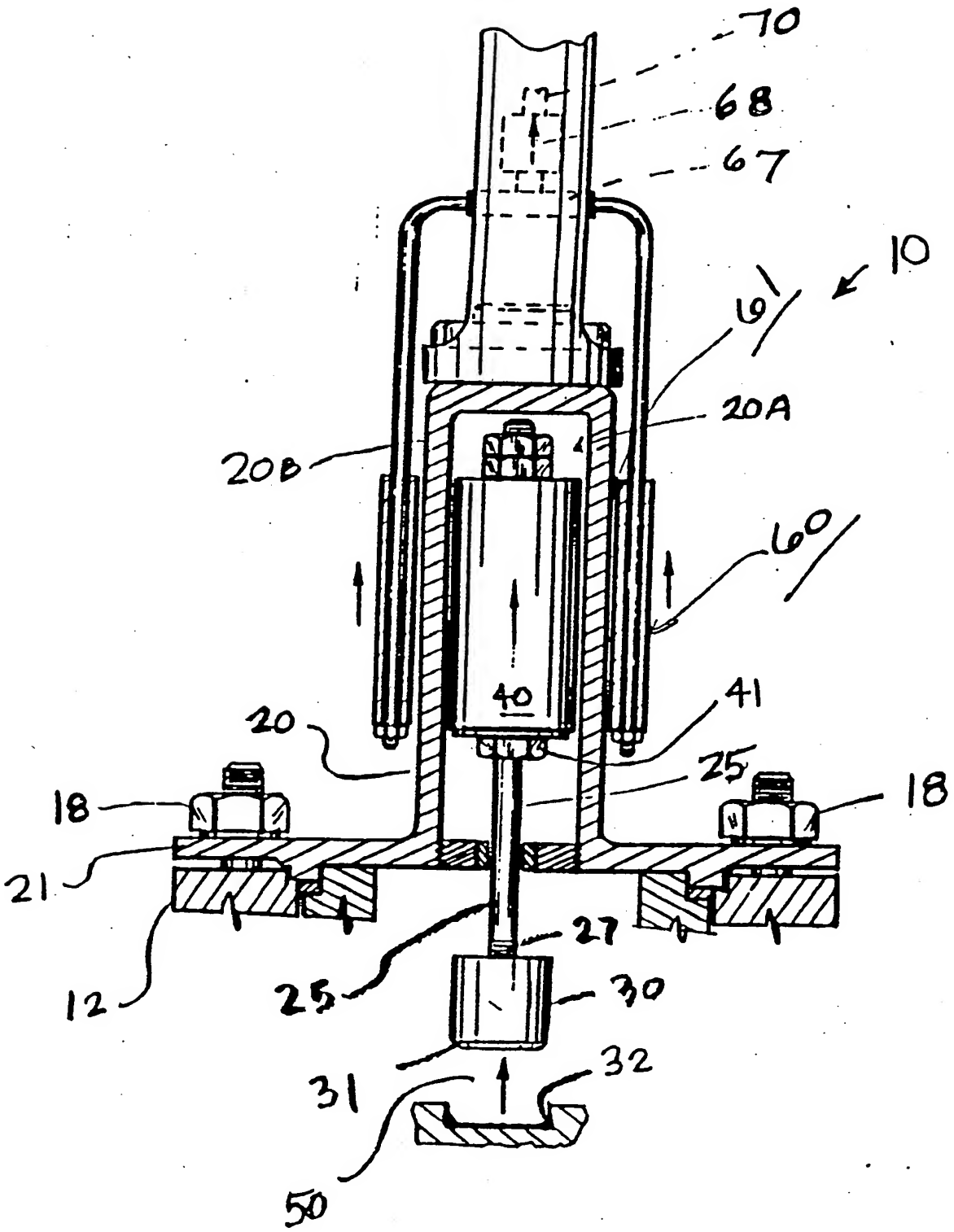

FIG. 5

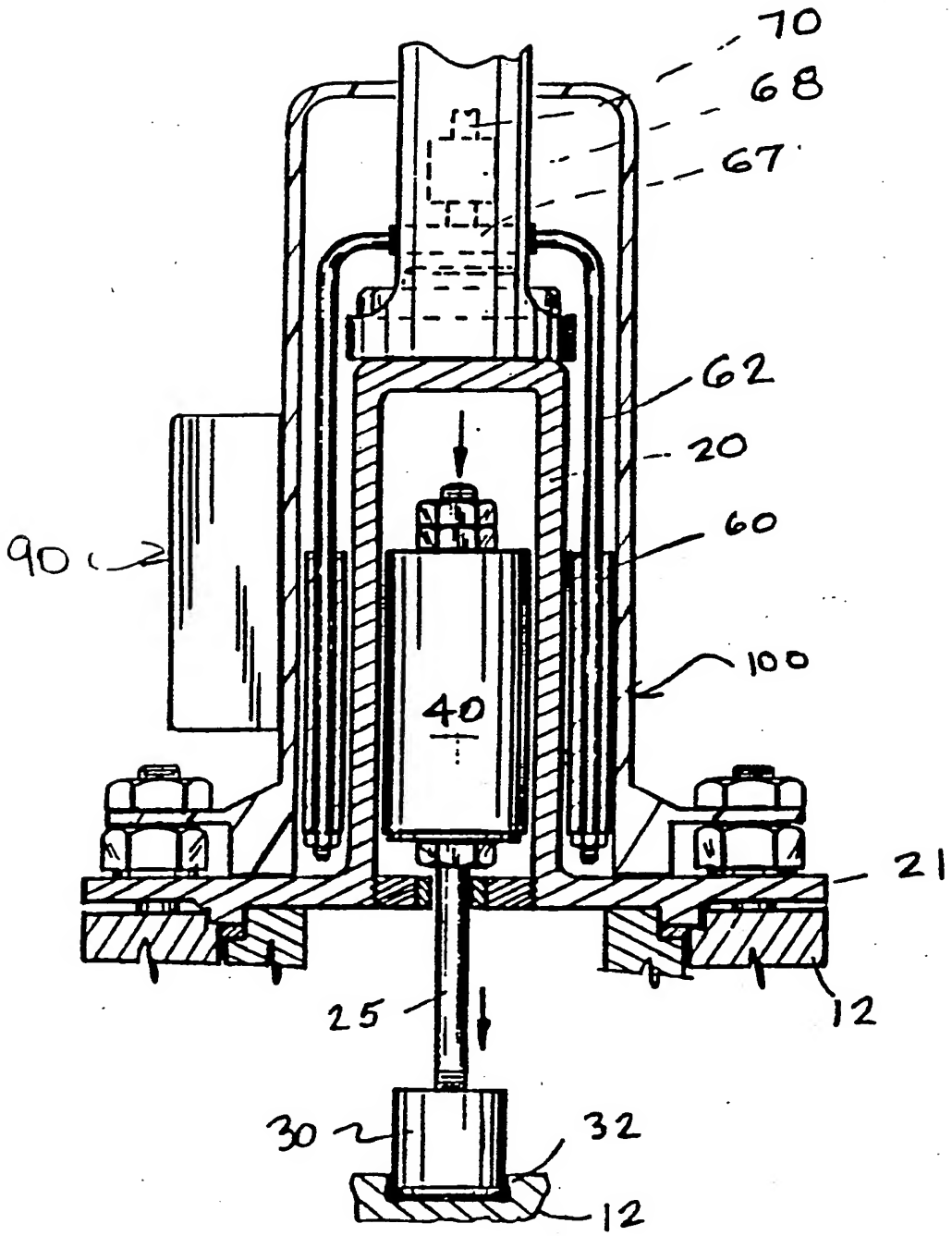

FIG. 6

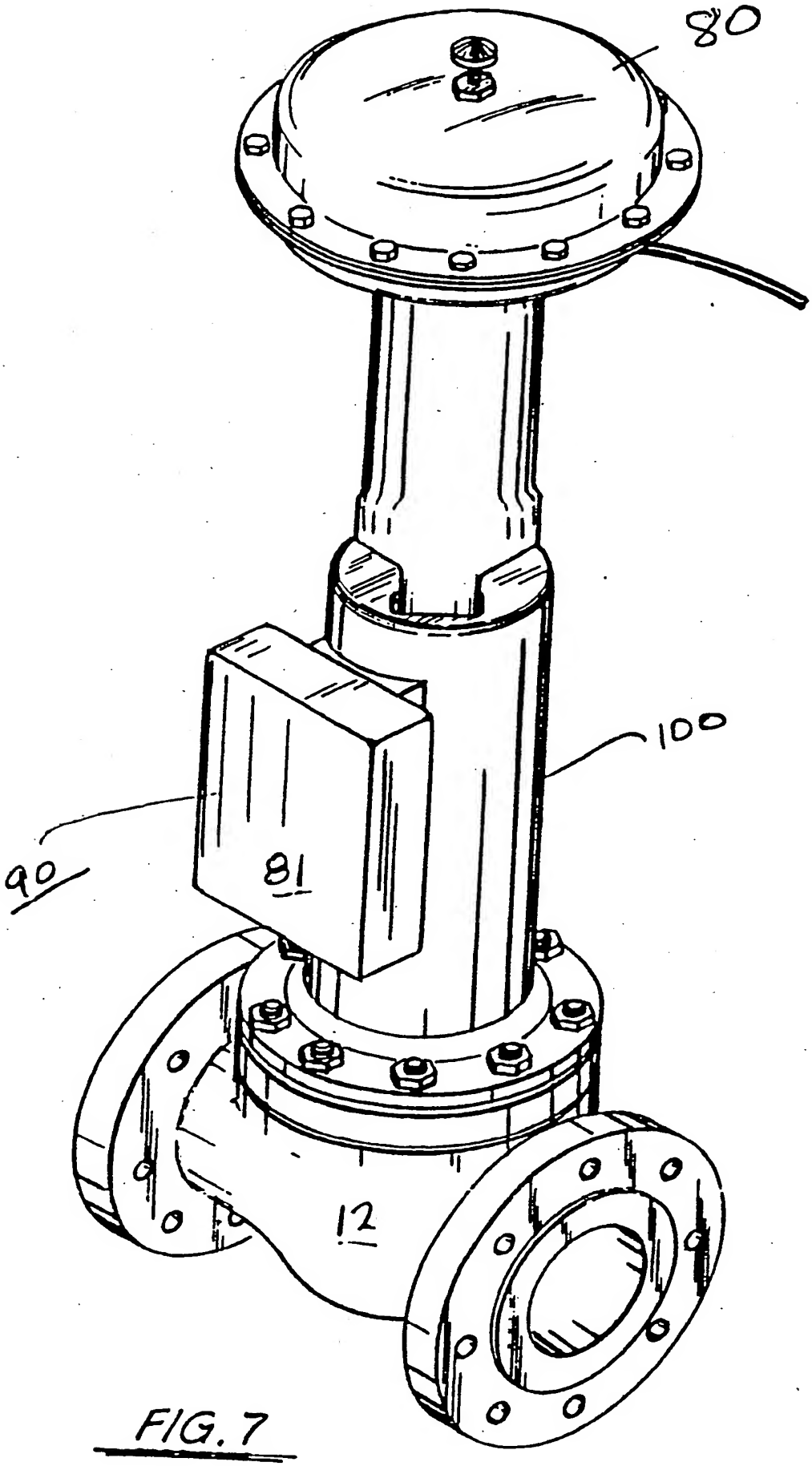

FIG. 7

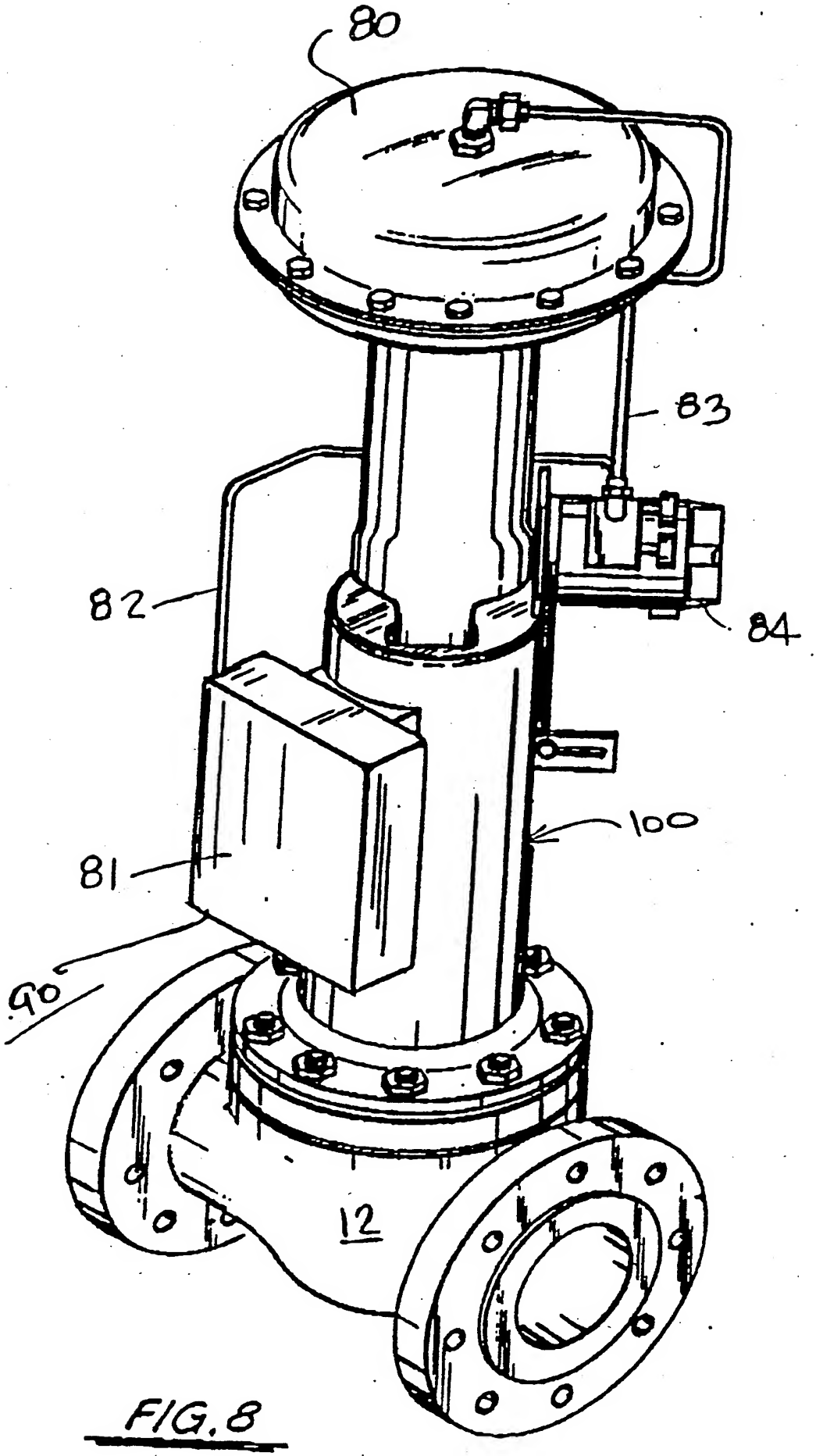

FIG. 8

DESCRIPTION

VALVE

The present invention relates to valves used for the handling of hazardous materials, chemicals, and chemical process fluids and the like, wherein a magnetically operated external sliding valve actuator moves a valve stem within a closed walled, sealed bonnet and along a linear path between open flow and closed flow positions.

There are numerous chemical plants, paper manufacturing facilities, and other factories used in the manufacturing of chemicals wherein sliding stem type valves (such as plug, globe, and the like) are used. These commercially available valves include a valve plug member operated by a stem which extends into and through a valve bonnet at a dynamic seal called a packing gland. Any type of leakage through this packing gland is at best only costly and at its worst can create an environmental hazard. These emissions, often called "fugitive emissions" can amount to a substantial environmental problem when numerous valves are leaking at a given facility. Such emissions can also trigger chemical reactions such as the formation of acids, that corrode the valve itself.

A sliding stem-type valve creates a special leakage problem as opposed, for example, to a rotary valve because the stem moves in a fashion which sequentially places the stem externally and internally of the housing during its normal operation. The chemical being conveyed can be moved from the inside of the valve to the exterior thereof, or trash can be carried from outside to the inside via the sliding stem. As an example, if the valve is conveying chlorine, molecules of the chlorine can move externally of the valve housing on the stem and contact free hydrogen in the surrounding air, forming hydrogen chloride. This acid can badly corrode the stem, and accelerate the escape of fugitive emissions.

As a solution to this problem, the present invention provides a method and apparatus that eliminates the dynamic seal of the sliding stem and the packing gland which forms a portion of tens of thousands of valves presently in service in the prior art. The present invention provides a seal which is static rather than dynamic and which can be manufactured as a new O.E.M. valve assembly, or in the form of a "kit" for retrofitting valves in existing service which are plagued with leakage at the stem and packing gland.

Various magnetically driven pump arrangements have been patented. For example, the Okulitch Patent 2,669,668, entitled "Magnetically Driven Centrifugal Pump" pertains to a pump construction having a magnetic coupling with magnetic attraction between rotors on opposites sides of a dividing wall.

Other patents that relate to the concept of magnetic drives for pumps include, for example, the Barotz Patent 3,172,364, entitled "Pump"; the McCoy Patent 3,299,819, entitled "Magnetic Drive"; the Pearson et al. Patent 3,572,981, entitled "Hermetically Sealed Pump"; the Zimmermann Patent 3,938,914, entitled "Pump Impeller And Coupling Magnet Structures"; the Miyahara Patent 3,941,517, entitled "Magnetic Hydraulic Pump"; the Dickinson Patent 4,266,914, entitled "Magnetic Drive Laboratory Pump"; the McCoy Patent 3,304,532, entitled "Pump Having Magnetic

Drive"; the Hauenstein Patent 4,645,433, entitled "Sealing Shroud Centrifugal Pump"; and the Mizuno Patent 4,722,661, entitled "Magnetic-Drive Centrifugal Pump.

Various valve constructions have been patented which use magnetic members in operation of the valve. The Gibson Patent 3,347,262, entitled "Magnet Actuated Sealed Valve", provides a rotary valve magnetic coupling comprising concentric, annular sleeves which are permanent magnet couplings. The Sherwood Patent 3,476,355, entitled "Magnetic Valve", uses a valve construction for controlling the flow of air, water, or light fluids, wherein a valve housing is made of insulating material having inlet and outlet portions, and a single moving part in the housing, comprises a freely movable valve closing and an opening disc of magnetic material normally supported by the housing over the valve outlet.

The Ignatjev Patent 3,625,473, entitled "Permanent Magnet Valve With Magnetic Operator", discloses a valve that includes a valving member which is movable between open and closed positions and which is actuated between those positions by respective interaction and non-interaction of two magnetic fields having axes which are disposed at an angle with respect to one another.

A rotary valve construction is seen in the Gigantino Patent 3,747,892, entitled "Magnetic Valve", wherein a valve structure having a driving sleeve magnetic is operated by a motor and a driven magnetic coaxial with the driving magnet connected to the valve.

Another rotary valve member is the subject of U.S. Patent 4,304,256, issued to Taiani, entitled "Torque Transmitting Assembly For Rotary Valve Member". The Kah, Jr. Patent 4,310,023, entitled "Magnetically Actuated Pilot Valve", includes a valve structure for fluid control systems which can direct a fluid pressure for operating a device or it can connect the device to drain. The Vanderlaan Patent 4,672,992, entitled "Direct Drive Valve-Ball Drive Mechanism", provides a ball-like member which is moved by a rotary force motor using a valve coupling.

A gate valve with a magnetic closure is the subject of U.S. Patent 4,747,577, issued to Dimock, entitled "Gate Valve With Magnetic Closure For Use With Vacuum Equipment". In the Dimock patent, a gate valve is provided for use with evacuable equipment and includes a housing having a pair of aligned ports in opposed walls. A valve seat surrounds one of the ports. A gate gate member is reciprocally translatable by means of a linear actuator in a direction generally normal to the central axis of the valve seat. Magnetic structures are operably associated with the gate and valve for pulling the gate and seat into sealing engagement for closure of the gate valve by exerting a closure force generally parallel to the axis of the valve seat. The linear actuator including a hollow cylinder having a piston movable therein and axially thereof which is magnetically coupled through the walls of the cylinder to an actuator member mechanically coupled to the gate for effecting reciprocal motion thereof.

The present invention provides an improved valve apparatus for use in the control of fugitive emissions in sliding stem valves that move between open flow and closed flow positions in order to precisely control flow and valve the flow of a hazardous fluid product in a petrochemical plant, chemical process plant, or the like.

The apparatus includes a valve body having a longitudinally extending flow bore, with a valve seat being positioned within the flow bore defining an opening that communicates with the flow bore. A valving member is moveable between open and closed flow positions for sealing the opening by registering upon the valve seat in the closed position. A sliding valve stem extends laterally from the housing at generally right angles to the longitudinally extending flow bore and housing, for moving the valving member along a linear path between open and closed positions. A bonnet, connectable to the valve body forms a sealed envelope over the entire valve stem. This bonnet is

a closed wall structure not having a packing gland, so that there is not a sliding relationship between the bonnet at the packing gland and the valve stem through which fugitive emissions can escape.

A magnetic member is positioned externally of the bonnet for forming a magnetic field inside the bonnet, the magnetic member being slideably supported for movement along the line generally parallel to the valve stem. In the upper end portion of the stem carries an enlarged member that moves with the magnetic field when the magnetic member slides between open and closed positions.

In the preferred embodiment, the magnetic member includes portions externally of the bonnet and positioned at least on opposite sides of the stem, and preferably an annular sleeve which extends entirely around the bonnet.

In the preferred embodiment, the upper end portion of the stem carries a member having a cross section that approximates the cross section of the bonnet interior, and is preferably a large magnetic member.

In the preferred embodiment, the valve body has left and right inlet and outlet portions with the valve seat being positioned generally therebetween and the bonnet affixes to a bolt circle portion of the valve body adjacent the valve seat generally between the inlet and the outlet.

The present invention also provides an improved method for modifying in situ sliding stem valves having a valve body with a valving member carried by a sliding stem that extends through a packing gland of the sliding stem valve bonnet in order to prevent fugitive emissions at the packing gland. As part of the method, the existing valve bonnet is removed. The valve stem is then closed with a laterally extending closed wall bonnet structure that entirely seals the valve stem and adjacent fluids so that fluids are contained within the valve body and the bonnet. An external operator positioned adjacent the bonnet moves the stem with a magnetic field that is preferably formed by the external operator (which can be a permanent magnet in the shape of a sleeve) and an internal magnet attached to the valve stem

movement of the operator then moves the stem, as the magnets remain adjacent one another. However, the magnetic field could be a single magnetic member, either the magnetic sleeve externally surrounding the bonnet, or a cylindrical permanent magnet carried inside the bonnet on the valve member.

For a further understanding of the nature, objects, and advantages of the present invention, reference should be had to the following detailed description, taken in conjunction with the accompanying drawings, in which like reference numerals denote like elements, and wherein:

Figure 1 is a perspective view of the preferred embodiment of the apparatus of the present invention;

Figure 2 is a perspective, partially cutaway view of the preferred embodiment of the apparatus of the present invention;

Figure 3 is a partial exploded perspective view of the preferred embodiment of the apparatus of the present invention;

Figure 4 is a partial, sectional elevational view of the preferred embodiment of the apparatus of the present invention illustrating a closed flow position;

Figure 5 is a partial sectional elevational view of the preferred embodiment of the apparatus of the present invention illustrating the valve in an open flow position;

Figure 6 is a sectional elevational view of the preferred embodiment of the apparatus of the present invention in a closed flow position;

Figure 7 is a perspective view of the preferred embodiment of the apparatus of the present invention showing the valve stem position transmitter; and

Figure 8 is a perspective view of another embodiment of the apparatus of the present invention showing the connection of the valve stem position transmitter and the actuator stem positioner.

Figure 1 shows in perspective view, the preferred embodiment of the apparatus of the present invention designated generally by the numeral 10. Valve apparatus 10 includes a valve body 12 having an inlet 13 and an outlet 14 each of which can be provided with flanged connections 15, 16 respectively for bolting the valve body 12 into a flow line.

The central portion of the valve body 12 includes an upper, generally flat surface 17 receptive of valve bonnet 20 (Figure 3) which provides a corresponding mating flange 21 having a plurality of openings 22 for bolting the flange 21 and the bonnet 20 to the valve body 12 at surface 17 using the plurality of bolted connections 18 arranged in a circle, as shown in Figure 1.

An internal valve stem 25 preferably in the form of an elongated metalic rod having threaded portions 26, 27 at its ends moves the valving member 30. The lowermost end portions of the stem 25 carries a valve plug 30 which is preferably cylindrical in shape having a valving end portion 31 which registers upon valve seat 32 (see Figure 5). Generally opposite valving member 30, an internal magnetic member 40 is provided, which is preferably cylindrical, having an internal bore (not shown) which allows the magnet 40 to be assembled upon stem 25 and held in position with a plurality of bolts 41. Magnetic member 40 can be a permanent magnet.

The bonnet 20 provides a closed wall sealed structure. The flange 21 portion of the bonnet forms a fluid tight seal with valve body 12 which can be made fluid tight by torquing the plurality of bolts 18 which form a circular arrangement, as shown in Figure 1. However, the closed wall structure of the bonnet 20 extends completely around the entire stem 25 which is an improvement over prior art designs wherein the stem extends through a packing gland located in the top of the bonnet.

In Figure 5, the valve 10 apparatus is shown in a fully up position wherein the valving member 30 has in this case

lifted off seat 32, as shown by the arrow 50. Thus, the stem 25 has been lifted to its uppermost position within the interior 20A of bonnet 20. It should be understood that the embodiments shown illustrate a push-down-to-close valve. However, the present invention will work as well with push-down-to-open valves.

The member 40 has a cylindrical cross section which closely approximates but is slightly smaller than the internal cross sectional area of the interior 20A of bonnet 20, as shown in Figure 5. The member 30 is lifted upwardly by means of an annular, external permanent magnet sleeve 60 (Figures 3 and 5) which extends about the bonnet 20, having an internal wall 61 which is of corresponding size to the external wall 20B of bonnet 20.

Yoke 62 affixes to sleeve 60 at a pair of openings 63, 64. Yoke 62 includes a pair of spaced-apart rods 65, 66 which are attached to a disc 67 that is moved upwardly and downwardly by means of connector rod 70. The connector rod 70 extends upwardly and attaches to diaphragm operator 80 which can be a conventional diaphragm type operator which is driving with fluid pressure in order to raise and lower rod 70. Thus, in Figure 1, the overall view of the valve illustrates the valve in a down position wherein the magnetic sleeve 60 has moved downwardly, as shown by the arrows 51, to a downward and in this case closed flow position. In Figure 2, the arrows 50 indicate upward movement of the sleeve 60.

The uses of these valves are generally, but not limited to, for the purpose of either process shutdown or process control. While it is necessary and appropriate that the position of the valve (opened, closed, or somewhere in-between) be known, it is generally accepted that the position of the valve plug in process control or throttling service is most important.

In many cases this style of valve is used in the control of certain processes in which it is necessary to know the position of the valve plug. The position may be either visually indicated or transmitted to a controlling

device by a variety of means such as a pneumatic or electronic signal.

It is of note that the closer one can come to knowing the actual position of the valve plug itself, as opposed to the position implied by some other member of the valve apparatus, such as the actuator stem, the greater the accuracy of control and the confidence of the operator.

In order that the device disclosed be of greater utility to and meet the requirements of industry, the use of an external stem position indicator is disclosed. Given that the valve plug, valve plug stem, and the internal magnetic coupling device form an assembly, the position of one will generally indicate the position of the others. Thus, the use of a valve stem position indicator/transmitter operating by means of reacting to the change in position of the internal magnetic coupling will be used.

It is necessary to confirm that the valve stem has in fact moved exactly as the actuator stem has moved in order to eliminate hysteresis in process control and to indicate when certain valves may become "stuck" due to internal failure or clogging.

In Figures 6-8, there is seen a valve stem position feedback transmitter which is designated generally by the numeral 90 and which attaches to a safety shroud 100 that defines a mounting over the entire valve bonnet assembly (see Figure 6). In Figure 8, a perspective view of the entire valve assembly illustrating the valve stem position feedback transmitter 90 is shown while Figure 7 illustrates an alternate embodiment of the valve stem position indicator.

The valve stem position indicator 81 could be a pointer with a scale. The pointer would slide with the magnetic field. In Figure 8, the position indicator 81 is a feedback transmitter having an output line 82 that communicates with the valve actuator stem position controller 84, coupled via line 83 to diaphragm actuator 80.

In view of the numerous modifications which could be made to the preferred embodiments disclosed herein without

departing from the scope or spirit of the present invention, the details herein are to be interpreted as illustrative and not in a limiting sense.

CLAIMS

1. A sliding stem valve apparatus comprising:

a) a valve body having a longitudinally extending flow bore with inlet and outlet end portions;

b) a valve seat, positioned in the flow bore and defining an opening that communicates with the flow bore;

c) a valving member movable between open flow and flow closed positions, for sealing the opening by registering the valving member upon the valve seat in the closed position;

d) a sliding valve stem, that extends laterally away from the housing at an angle with respect to the longitudinally extending flow bore, for moving the valving member along a generally linear path between open flow and closed flow position;

e) a bonnet, connectible to the valve body for forming a sealed envelope with the body over the entire valve stem;

f) means for forming a magnetic field that extends internally of the valve bonnet;

g) an actuator positioned externally of the bonnet for moving with the valve stem and the magnetic field, the magnetic field being movable along a line generally parallel to the valve stem;

h) the upper end portion of the stem carrying a stem member that moves with the magnetic field when the actuator moves between open and closed flow positions; and

i) at least one of the operator and the stem operator member defining a portion of the magnetic field.

2. An apparatus as claimed in claim 1, wherein

the magnetic field is a magnetic member positioned internally of the bonnet.

3. An apparatus as claimed in claim 1, wherein the magnetic field is a magnetic member positioned externally of the bonnet.

4. An apparatus as claimed in claim 3, wherein the magnetic member is an annular sleeve that extends around the bonnet.

5. An apparatus as claimed in claim 4, wherein the sleeve is a cylindrical member of generally uniform diameter and the valve member and enlarged member are each cylindrical members having larger diameters than the stem diameter.

6. An apparatus as claimed in claim 4 or 5, further comprising a valve actuator mechanism for moving the magnetic field.

7. An apparatus as claimed in claim 6, further comprising a yoke that supports the annular sleeve for movement.

8. An apparatus as claimed in claim 7, wherein the actuator means includes an elongated shaft generally aligned with the valve stem.

9. An apparatus as claimed in claim 8, wherein the actuator means include a housing attached to the bonnet opposite the valve body.

10. An apparatus as claimed in any one of the preceding claims, wherein the upper end portion of the stem carries a cylindrical member with a cross section that approximates the cross section of the bonnet interior.

11. An apparatus as claimed in any one of the preceding claims, wherein the valve body has left and

right inlet and outlet portions with the valve seat being positioned generally therebetween, and a bolt circle adjacent the valve seat on the outside of the body, and the bonnet affixes to the valve body at the bolt circle.

12. A sliding stem valve apparatus comprising:

a) a valve body having a longitudinally extending flow bore with inlet and outlet end portions;

b) a valve seat, positioned in the flow bore and defining an opening that communicates with the flow bore;

c) a valving member movable between open flow and flow closed positions, for sealing the opening by registering the valving member upon the valve seat in the closed position;

d) a sliding valve stem, that extends laterally away from the housing at an angle with respect to the longitudinally extending flow bore, for moving the valving member along a generally linear path between open flow and closed flow position;

e) a bonnet, connectible to the valve body for forming a sealed envelope with the body over the entire valve stem;

f) means for forming a magnetic field that extends internally of the valve bonnet;

g) an actuator positioned externally of the bonnet for moving with the valve stem and the magnetic field, the magnetic field being slidably movable along a line generally parallel to the valve stem;

h) the upper end portion of the stem carrying a member that moves with the magnetic field when the magnetic member slides between open and closed positions; and

i) at least one of the valve actuator and the

member defining a portion of the magnetic field;

j) valve stem position indicator or transmitter means carried externally of the bonnet for indicating or transmitting the position of the valve stem.

13. An apparatus as claimed in claim 12, wherein the indicator means is a sliding member positioned externally of the bonnet.

14. An apparatus as claimed in claim 13, wherein the member moves a distance that corresponds to movement of the stem.

15. An apparatus as claimed in claim 12, 13 or 14, wherein the indicator means includes a scale to indicate the degree of valve opening.

16. A method of modifying a valve having a valve body and a valving member carried by a sliding stem that extends into a removable valve bonnet and through a packing gland in order to prevent fugitive emissions at the interface between the stem and the packing gland, comprising the steps of:

a) removing the existing valve bonnet;

b) covering the entire valve stem with a closed wall bonnet that seals the area about the stem and contains fluids adjacent thereto;

c) adding an external operator to the bonnet and valve assembly that moves the stem with a magnetic field that is formed by using a magnetic member so that the magnetic field extends between the operator and the stem.

17. A method as claimed in claim 16, wherein in step "a", the existing valve bonnet is unbolted from the valve body, and the closed wall bonnet is bolted to the valve body at the same bolted connection that held the existing bonnet.

18. A method as claimed in claim 16 or 17, wherein in step "c", the external operator is a magnetic member.

19. A method as claimed in any one of claims 16 to 18, wherein in step "c", the stem carries a magnetic member at its upper end portion.

20. A method as claimed in any of claims 16 to 19, wherein in step "c", the external operator is a magnetic member and one end portion of the stem carries a magnetic member so that the magnetic field is comprised of magnets positioned both internally and externally of the bonnet.

21. A method as claimed in claim 20, wherein at least one of the magnets is a permanent magnet.

22. A method as claimed in claim 20, wherein at least one of the magnets is an electromagnet.

23. A method as claimed in any one of claims 16 to 22, wherein in step "c", the external operator is moved using fluid power.

24. A method as claimed in any one of claims 16 to 23, wherein the magnetic field is formed by a permanent magnet.

25. A method as claimed in any one of claims 16 to 23, wherein the magnetic field is formed by an electromagnet.

26. A sliding valve apparatus substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

27. A method of modifying a valve substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

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